

RESEARCH NOTE

Arm abnormality in *Octopus hubbsorum* (Mollusca: Cephalopoda: Octopodidae)

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Abstract: *Octopus hubbsorum* Berry, 1953 occurs in a wide region of the oriental tropical Pacific. This is the principal target species in the octopus fisheries in Mexico. A female with abnormally bifurcated second arm was collected from an artisanal fishery in Puerto Angel, Oaxaca, Mexico.

Key words: Octopus, Oaxaca, bifurcation, *Hox* genes

Cephalopods are a diverse group of highly derived molluscs, including nautilus, squids, cuttlefish, and octopuses. Regeneration in cephalopods has been observed and reported by several workers. Toll and Binger (1991) documented different cases of arm anomalies in octopoda, and González and Guerra (2006) mentioned cases of bilateral hectocotilization in squids and cuttlefish. The most common anomalous condition of the arms of octopuses is the bifurcation or polyfurcation of the arms, particularly at the tips (Toll and Binger 1991).

Parona (1900) described bifurcation in an arm of *Eledone moschata* Lamarck, 1798 and the first left arm of *Octopus vulgaris* Lamarck, 1798 in the Mediterranean Sea. Kumpf (1960) described a male specimen of *O. briareus* Robson, 1929 with the third left arm divided into two branches. It showed a well-developed web between these divisions as found at the bases of the normal arms in the species. In an extreme case reported by Okada (1965 in Toll and Binger 1991), seven of the eight arms of a specimen of *Octopus* sp. were involved in polycotomous branching resulting in a total of ninety terminal branches. Palacio (1973) reported cases of double unilateral hectocotilization in *O. vulgaris* and *O. selene* Voss, 1971. Gleadal (1989) studied the anatomy of octopuses with seven arms, with special reference to the arrangement of brachial nerves. The first case of true hexapody among the Octopoda, resulting from bilateral agenesis of one arm pair, was described by Toll and Binger (1991) for a male *Pteroctopus tetracirrhus* della Chiaje, 1830. The same authors also reported the first case of decapody in octopuses for a male *O. briareus* and concluded that both conditions apparently result from developmental anomalies of the embryonic arm anlagen.

Knowledge of octopus from the central Eastern Pacific (20°N–15°S) is limited to a very few species and biological

characteristics. In fact, data on octopods from the central and south Mexican Pacific are very scarce and fragmentary; *Octopus hubbsorum* Berry, 1953 is the principal target species in the octopus fisheries (Alejo-Plata *et al.* 2009, López-Uriarte and Ríos-Jara 2009, Domínguez-Contreras *et al.* 2013). Records on disease conditions are scarce (Pascual *et al.* 2006) and oil anomalous conditions are absent. The objective of this study was to describe bifurcation in an arm of the *O. hubbsorum*.

A female *Octopus hubbsorum* with second arm bifurcated was found among a sample of 115 specimens collected by scuba diving (5–10 m depth) as part of an artisanal fishery in Mexico, El Faro Puerto Angel (15°39'N, 96°31'W) during January to October 2012. The specimens were examined and identified using the Roper *et al.* (1995)'s taxonomic key together with the Berry (1953)'s original description.

Mantle length (ML), total length (TL), and total body weight (BW) were taken. Maturity was determined by presence of mature oocytes in females. The octopus was formalin-fixed and deposited in the cephalopod collection at the Universidad del Mar at Oaxaca, Mexico.

The specimen conforms well to all of the morphological features typically associated with the species. The main measurements of this female were 275 g body weight and 75 mm ML. This female was immature. Its stomach was full. Except the arm bifurcations, this female did not show any other type of anomaly (Fig. 1A).

Length of the arm before the split was 70 mm; the arm was divided into two branches, the longest branch (215 mm) and shorter (140 mm) had a localized large knob (approximately 5 mm diameter) in the later margin, and regeneration of arm tip (Table 1). An unusual feature was the presence of a

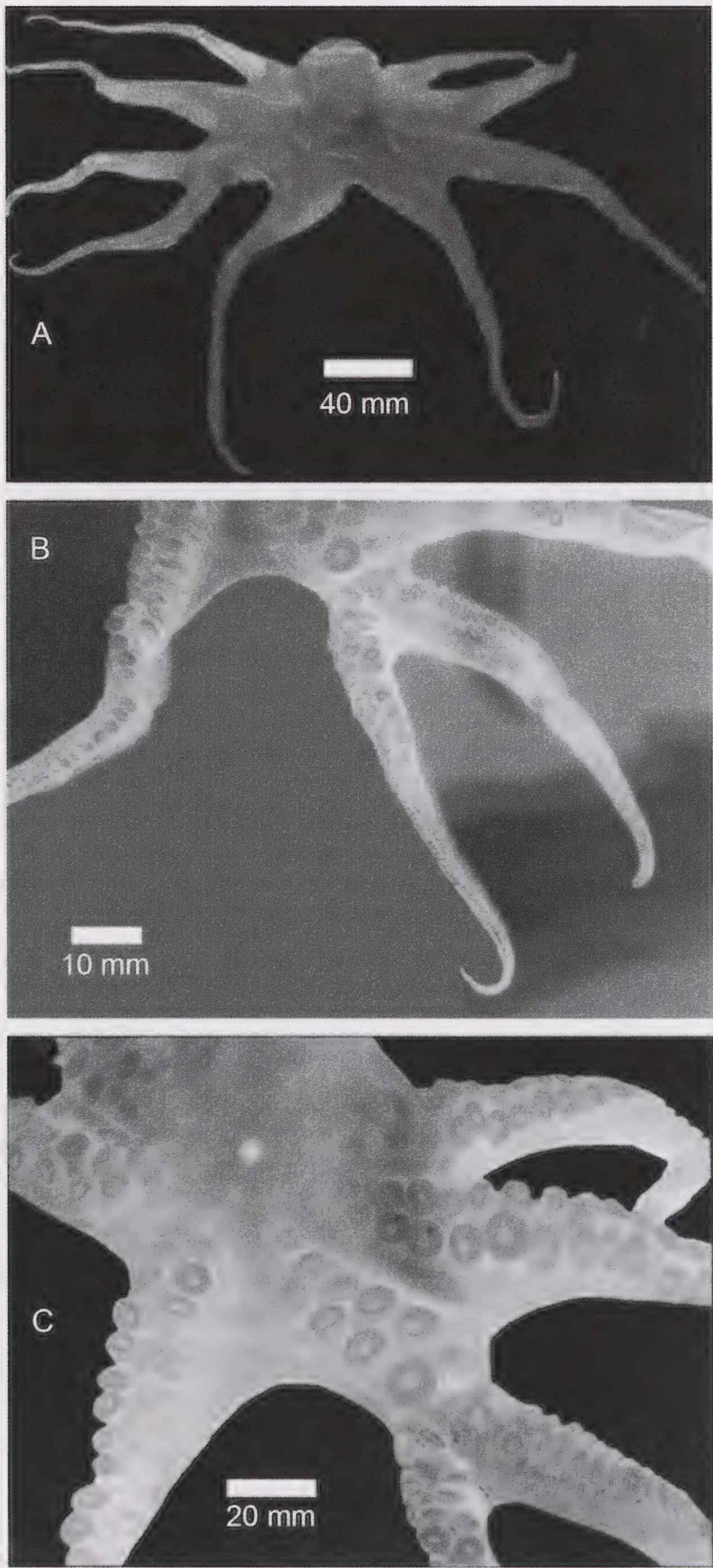


Figure 1. A, Dorsal view of *Octopus hubbsorum*; B, C, Oral view of brachial crown, shows second bifurcated arm.

well-developed web (depth 1.2 mm) between the two divisions as found uniting the bases of normal arms in this species. The suckers are biserial in the normal fashion from the mouth to immediately below the junction. The second row of

Table 1. Morphological measurements of the specimen of *Octopus hubbsorum* with arm abnormality.

Biometrics	Measurement (mm)
Total length	380
Mantle length	75
Mantle width	45
Head width	38
Arms length (to base of split)	70
Arms length of left branch	215
Arms length of right branch	140
Depth of web	31
Arm order	2, 4, 3, 1

suckers, distally from the center of the junction, is composed of one sucker across. The last row of suckers on the main stem has five suckers across the arm. On each of the divided sections the paired sucker arrangement found on the main stem is present (Figs. 1B–C). All remaining arms are normal. Figure 2 shows the body weight-mantle length relationship of the 115 specimens in the sample. The open square represents the female with abnormalities in the arm.

The arm branching observed in *Octopus hubbsorum* does not appear to be the result of any arm injury; similar results are described by Kumpf (1960) in *O. briareus*. Toll and Binger (1991) suggested a possible relationship of polyfurcation of arm tips in the Octopoda with regenerative processes in amphibian limbs. It is conceivable that additional cases of true arm agenesis in octopods have gone undiagnosed because of the frequency of routine injury-induced arm loss. Also, the regenerative process associated with arm repair is normally easily visualized until the arm has regained almost its entire length.

Homeobox genes are a large family of similar genes that direct the formation of many body structures during early embryonic development. Genes in the homeobox family are involved in a wide range of critical activities during development, include directing the formation of limbs and organs along the anterior-posterior axis and regulating the process by which cells differentiate; mutations in these genes are responsible for a variety of developmental disorders. For example, mutations in the *Hox* group of homeobox genes typically cause limb malformations. The expression of *Hox* genes provides the basis for anterior-posterior axis specification throughout the animal kingdom (Gilbert 2013).

Lee *et al.* (2003) reported the first *Hox* genes expression patterns in cephalopod mollusk. The results show that *Hox* genes correctly expressed have been repeatedly recruited and in different ways in the origin of the new cephalopod structures. It was demonstrated that the structure of the brachial crown, funnel, stellate ganglia of the mantle and the neurons

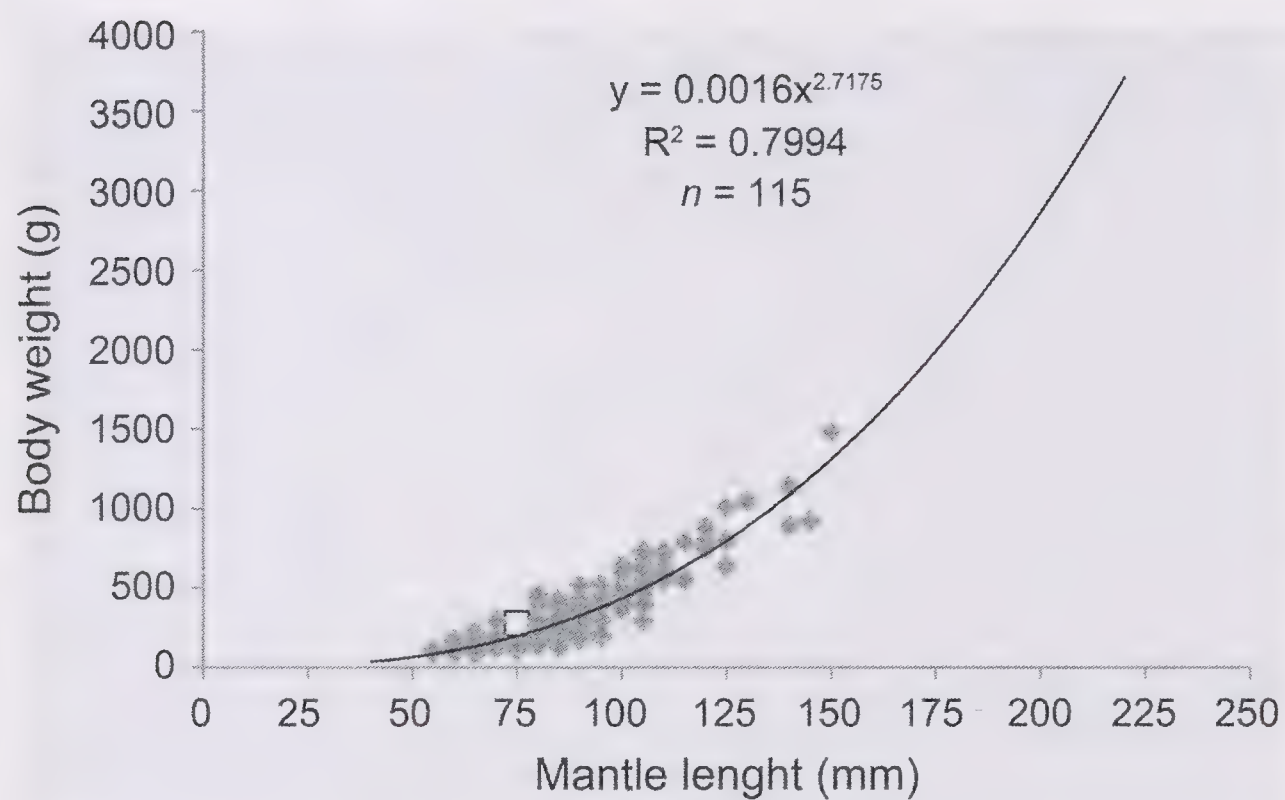


Figure 2. *Octopus hubbsorum* body weight–mantle length relationship. Open square indicates octopus with the bifurcate arm.

that regulate their behavior, including the ganglia and the lobes of the nervous system, are the expression of multiple *Hox* genes interacting coordinately during the embryonic development of that species; each arm pair expresses a unique combination of these genes.

The abnormality observed in *Octopus hubbsorum*, could be due to a *Hox* genes mutation. It was demonstrated that *Hox* genes determine where limbs and other body segments will grow in a developing larva. Also, that mutation in any one of these genes can lead to the growth of extra, typically non-functional, body parts in invertebrates and can produce visible phenotypic changes (Lodish *et al.* 2003).

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